United States
Department of
Agriculture

Forest Service

Forest Pest
Management

Davis, CA

FOREST SERVICE AERIAL SPRAY COMPUTER MODEL FSCBG 4.0

USER MANUAL

FPM 91-1
SEPTEMBER 1990

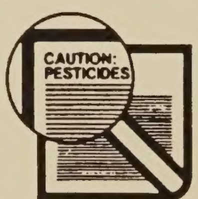
Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.



FPM 91-1
C. D. I. Report No. 90-06
September 1990

FOREST SERVICE AERIAL SPRAY COMPUTER MODEL FSCBG 4.0

USER MANUAL

Prepared by:

Milton E. Teske
Thomas B. Curbishley

Continuum Dynamics, Inc.
P. O. Box 3073
Princeton, NJ 08543

Contract No. 53-04H1-9-0510

Prepared for:

USDA Forest Service
Forest Pest Management
2121C Second Street, Suite 102
Davis, CA 95616

John W. Barry
Project Officer

ABSTRACT

The version of FSCBG (USDA Forest Service Cramer Barry Grim) described in this manual combines and implements mathematical models for aircraft wake effects, gaussian line source dispersion, droplet evaporation, canopy penetration, and ground and canopy deposition. FSCBG is designed to account for the atmospheric dispersion, transport, and deposition of all aerial spray material from the time of release until all spray material is either deposited or, in the case of spray drift, until the spray concentration and deposition levels become insignificant. Specific calculations made by FSCBG include spray concentrations, dosages and depositions above, within and below forest canopies, resulting from aerial spray releases made along single or multiple flight paths. Important applications of FSCBG are the optimization of spray program design and operation with respect to the selection of aircraft spray systems (aircraft and spray devices), flight altitudes, swath widths, spray rates, evaluation and analysis of field measurements of spray deposition, assessments of the environmental impact or hazard posed by aerial spray operations, and assessments of the effectiveness of defensive military strategies.

The development of FSCBG was accomplished initially by the H. E. Cramer Company, Inc. and subsequently by Continuum Dynamics, Inc. under contracts funded by USDA Forest Service, Forest Pest Management, Washington Office, and U. S. Army Dugway Proving Ground, Utah.

TABLE OF CONTENTS

FOREWORD

The version of FSCBG (USDA Forest Service Cramer Barry Grim) described in this user manual contains extensive information and equations that predict the behavior and fate of droplets released in the atmosphere. The constructs of the model use both empirical and theoretical knowledge of physical sciences and engineering. The codes comprising the FSCBG model have undergone various levels of development and field evaluation over the past two decades. Default values for each model should be used only in those cases where the user manual states their appropriateness or when the user understands the meaning of the quantity. The model should be considered a dynamic system that will be updated, revised, and expanded as use and need dictate.

This is the latest user document prepared in support of FSCBG, a complete-wake aerial spray dispersion model. This manual describes the use of FSCBG on desktop personal computers.

Previous versions of FSCBG were developed from program source coded by the H. E. Cramer Company, Inc. and provided to Continuum Dynamics, Inc. by the U. S. Army Dugway Proving Ground. This version represents a complete rewrite of the user interface, a correction and verification of all computational exercises in the code, and a significant extension of its graphical capability.

Comments and suggestions regarding FSCBG and this manual may be forwarded to:

FSCBG System Manager
USDA Forest Service
Forest Pest Management
2121C Second Street, Suite 102
Davis, CA 95616
(916) 758-4600

FSCBG User Group
Continuum Dynamics, Inc.
P. O. Box 3073
Princeton, NJ 08543
(609) 734-9282

1. INTRODUCTION

The FSCBG computer model for predicting aircraft spray dispersion and deposition above and within forest canopies resulted from the merging of models for simulating the effect of the aircraft wake on the behavior of released spray material, the penetration of spray material into a forest canopy, and determining optimum swath widths, application rates, and aircraft altitudes to achieve specific objectives. FSCBG combines and implements mathematical models for aircraft wake effects, gaussian line source dispersion, droplet evaporation, canopy penetration, and ground and canopy deposition. The USDA Forest Service selectively uses aerial spray applications to control forest pests while the U. S. Army is interested in assessing the effectiveness of chemical and biological defensive strategies. Both agencies are interested in achieving a more complete understanding of the behavior of spray material from the time spray is released from the aircraft until it has been deposited or, in the case of spray drift, diffused to concentration/dosage levels that are environmentally insignificant. Because mathematical spray dispersion models are useful in determining interactions of the many factors affecting spray operations, the USDA Forest Service and U. S. Army have supported the application and development of these models over the last twenty years.

Simplified aerial line source models developed for the U. S. Army (Cramer et al. 1972) were applied early in the 1970s to determine optimum swath widths and application rates for use in pilot tests of insecticides under consideration at that time for control applications in western forests (Barry and Ekblad 1983). The implications of these early efforts in the use of mathematical models to improve the planning, conducting, and subsequent analyzing of spray program operations and results were noted (Dumbauld, Cramer and Barry 1975), and led to field validation (Boyle et al. 1975) and the development of the CBG model (Dumbauld, Rafferty and Bjorklund 1977). A first reported application of this technology (Waldron 1975) estimated the amount of spray material needed to control an outbreak of spruce budworm. Further work (Dumbauld and Bjorklund 1977) determined offset distances required for various aircraft to ensure that drift from spray blocks posed no determinable environmental hazard to exclusion areas (waterways, homes, etc.) in the vicinity of the spray blocks.

Continued success in simulating field experiments lead to the development of FSCBG (Dumbauld, Bjorklund and Saterlie 1980). FSCBG was subsequently applied to the development of optimum swath widths, application rates, and aircraft altitudes in a later Maine project (Dumbauld,

Bowman and Rafferty 1980), and for a pilot project in the Withlacoochee State Seed Orchard (Rafferty et al. 1981).

Further refinements to the model included the addition of the near-wake model AGDISP (initially developed by Bilanin and Teske 1984, reported in Bilanin et al. 1989, and most recently enhanced in Teske 1990) into FSCBG, and the replacement of the original canopy penetration model (Grim and Barry 1975) by an analytic formulation.

Original user documentation was subsequently replaced (Bjorklund, Bowman and Dodd 1988) and modified when FSCBG became operational on personal computers (Curbishley and Skyler 1989). Further field data comparisons have been made for forested sites at Red Bluff (Rafferty et al. 1989) and a Douglas-fir seed orchard in Oregon (Teske et al. 1991).

2. GENERAL DESCRIPTION

FSCBG implements a near-wake aircraft effects model (AGDISP), a gaussian line source dispersion model, a droplet evaporation model, and a canopy penetration model to calculate the concentration, dosage, and deposition above and within a forest (vegetative) canopy downwind from multiple aircraft spray lines or swaths. The program is written in FORTRAN 77 and is operational on personal computers (Microsoft FORTRAN compiler).

Version 4.0 varies considerably from previous versions of FSCBG. The user interface (how the user of FSCBG interacts with the program) has been completely rewritten. The previous interactive menu approach has been retained, but the structure of menus, the groupings of variables within these menus, and the way in which the user maneuvers through the menus have been significantly altered. Terminology has been updated, input requirements have been simplified, and numerous user-conveniences have been added. Graphical capabilities have been expanded, and the concept of data base management has been introduced with the addition of libraries of aircraft, spray material, meteorology, and previously saved user data.

Further enhancement of FSCBG is a commitment of the USDA Forest Service. Version 4.0 is supported by a User Group, and periodic Training Sessions are held to enhance performance in the use of the program.

3. NOMENCLATURE

FSCBG assumes a basic knowledge of the aerial application scenario, including some understanding of aircraft and forests. For a point of common reference, the following definitions and concepts used in FSCBG are summarized:

Aircraft	Helicopter or fixed wing.
Canopy	The vegetative material (trees, shrubs, crops, etc.) that will capture a portion of the released material before it intercepts the ground.
Concentration (Peak)	Amount of material per volume collected.
Default Values	Current input variables (from FSCBG or an input file) before being modified.
Deposition	Amount of material per area collected.
Dispersion	Spreading of the released material due to atmospheric turbulence and wind.
Dosage	Total amount of material collected per volume, summed over all time.
Flight Line	Spray path of the aircraft.
Isopleth	Line of constant value.
Mixing Depth	Height over which the released material interacts with the ambient wind and deposits on the canopy or ground.
Near Wake	Wake option invoking the AGDISP aircraft wake model.
Net Radiation Index	Parameterization of evaporation and meteorological processes.

NMD	Number Median Diameter of spray drops, usually expressed in microns: half of the total number of drops is in drops larger than the NMD and half of the total number of drops is in drops smaller than the NMD.
Nominal Height	The height above the ground of the helicopter rotor blade or the aircraft primary wing.
Nozzle Horizontal Distance	Horizontal location of a nozzle relative to the aircraft centerline.
Nozzle Vertical Distance	Vertical location of a nozzle relative to the Nominal Height.
Planform Area	Surface area of an aircraft wing.
Receptor Grid	Points at which concentration, dosage and deposition will be predicted. As a general rule this grid should encompass and extend beyond the source geometry (flight lines), especially downwind in those model runs where a crosswind is used.
Rectangularly Loaded Wing	Assumed constant wing force loading across the entire wing span.
Release Height	Aircraft flight height measured from the ground (also the Nominal Height).
SDC	Size Distribution Calculation program to manipulate wind tunnel test data into workable drop size categories.
Semispan	One-half the aircraft wing span.
Settling Velocity	Speed achieved by the released material falling in the aircraft wake under gravity.
Source	The spray paths or flight lines followed by the spray aircraft.

Source Radius	Assumed overall size of the material cloud released from the nozzles.
Swath Width	Anticipated width of the deposition to achieve a desired level of material on the ground.
Tree Envelope	Statistical representation of a typical tree in the canopy.
Vegetative Element	A single leaf, stem, etc. that contains the essence of the canopy; the element that is quantified for the model.
VMD	Volume Median Diameter of spray drops, usually expressed in microns: half of the total volume is in drops larger than the VMD and half of the total volume is in drops smaller than the VMD.
Wake Settling	Wake option invoking a simple downwash field as representing the aircraft wake.

from the nozzle.

A single leaf, stem, etc. that [illegible] the canopy [illegible] for the model.

Volume Median diameter [illegible] usually expressed in microns. Half of the total volume is in drops larger than the VMD and half of the total [illegible] drops smaller than the VMD.

[illegible] involving a [illegible] as [illegible] the aircraft wake.

4. DATA INPUT

FSCBG is invoked by the user with the command

FSCBG < return >

In this notation < return > implies pressing the ENTER key on the keyboard. On personal computers FSCBG requires the use of data files resident in an accessible location. FSCBG works faster with faster machines, and, depending on the extent of the simulation involved, may consume great amounts of disk storage space.

A discussion of the operation of FSCBG follows, beginning with the data input menus. Entry in FSCBG is case insensitive (upper case or lower case is allowed).

The very first screen looks like this:

```
                          FSCBG

                      Forest Service
              Aerial Spray Dispersion Model

                       Version 4.0
                       Serial # 00001

              U.S. Department of Agriculture
                      Forest Service
                 Forest Pest Management


Continuum Dynamics, Inc.                           John W. Barry
P.O. Box 3073                        2121C Second St. Suite 102
Princeton, NJ 08543                              Davis, CA 95616
(609) 734-9282                                    (916) 758-4600
```

This screen identifies the version number (4.0) and the serial number (in this case 00001). This information is important when problems occur with the program. Each member of the FSCBG User Group has been given a separate and unique serial number to expedite solving such problems. This screen also gives the telephone numbers of the FSCBG System Manager and the Consulting Firm providing User Support.

The pressing of any key moves FSCBG to the Main Menu.

Main Menu:

```
Menu>
? help  <esc> go back  <return> select current

               Main Menu

             A-Files
             B-Data
             C-Calculations
             D-Results
             E-Setup
             F-EXIT

FSCBG 4.0        (untitled)
```

The Main Menu controls the flow of data from file naming, entry of data, model calculations, graphical presentation of results, program setup and eventual exit from FSCBG. This menu reflects several features present in all input menus to FSCBG:

1. The top line on the screen (presently blank) indicates the path taken to arrive at this menu. Since this is the Main Menu, no path yet exists.

2. The second line is the data entry line.

3. The third line provides helpful information.

4. The bulk of the screen offers the menu selection data.

5. The bottom line identifies the FSCBG run title.

The data entry line may contain one of the following indicators:

Menu >	Indicating the user is in a menu.
Table >	Indicating the user is in a table.
Real >	FSCBG is expecting a real number from the user.
Integer >	FSCBG is expecting an integer from the user.
String >	FSCBG is expecting a string of characters.

Library >   FSCBG is accessing one of its libraries of saved data.

The information line contains entry options available to the user at this point in the program. The help facility is not available in the present version of FSCBG.

Selection of a line in a menu is accomplished in one of two ways:

1. By using the cursor arrow keys (up and down) to move the highlight bar to the desired line; then pressing ENTER (thus selecting the current line with a < return >); or

2. Entering the line designation symbol (A, B, C, etc.), resulting in automatic selection of the designated line.

Exiting a menu is accomplished in one of two ways:

1. By using the cursor arrow key (up) to move the highlight bar off the screen at the top, then pressing ENTER; or

2. By pressing the ESCAPE key (< esc >) on the keyboard.

First-time operation of FSCBG on a computer generally requires that Setup be invoked, followed by Files, Data, Calculations, and Results.

Lower case line designation symbols imply that these options cannot be accessed by the user, either because they are not yet implemented or because previous information has not been entered by the user to permit access to these options.

In all that follows, only the path line and the menu selection data will be displayed.

Setup:

```
E Setup

               Machine-Specific Setup

             A-Device for Graphics Display     none
             B-Device for Graphics Hardcopy    none
             c-Graphics Hardcopy Destination
             D-Graphics Display Color Option   Color
             e-Graphics Hardcopy Color Option
             F-Save Setup
```

This menu enables the selection of machine-specific parameters needed to run FSCBG successfully. Unless computer systems have been changed, this menu only needs to be entered once to set default values. These selections are:

1. The appropriate graphics display device (the type and/or resolution of the screen).

2. The appropriate graphics hardcopy device.

3. The disk file path for the hardcopy results.

4. Display presentation in color or black/white.

5. Hardcopy presentation in color or black/white.

6. The option to save the setup information into a disk file for ease of operation (FSCBG will always test for a configuration file on startup, and read its contents if it is present).

The path line (the first line on the screen) indicates that a keystroke of "E" has brought FSCBG to Setup.

Device for Graphics Display:

```
EA Setup>Display Device

               Graphics Display Device

             A-none
             B-CGA 640x200 Mono
             C-EGA 640x350 16 Color
             D-VGA 640x480 16 Color
             e-Hercules
```

The available display devices are displayed. Selection of "none" will prevent FSCBG from displaying any graphical results on the screen.

The applicable monitor type is selected, and < return > is pressed to return to the Machine-Specific Setup Menu.

Device for Graphics Hardcopy:

```
EB Setup>Hardcopy Device

               Graphics Hardcopy Device

             A-none
             B-Tek 4014
             C-Tek 4105
             D-Tek 4107/4109
             E-HP Plotter
             F-PostScript
```

The available graphics hardcopy devices are displayed. The code necessary to interpret graphical results has been implemented into FSCBG for these specific Tektronix terminals, Hewlett Packard graphics library, and PostScript. Selection of "none" will require the user to manipulate the screen results (with a screen dump procedure). Any other device selection will permit access to Graphics Hardcopy Destination in the Machine-Specific Setup Menu.

Graphics Hardcopy Destination:

```
EC Setup>H/C Dest

               Graphics Hardcopy Destination

             A-Std Output
             B-Disk File
             C-Comm 1
             D-Comm 2
```

The available graphics destinations are displayed. The selection of Standard Output will send graphical results to the display devices connected to the personal computer parallel port. The selection of Disk File will write results into a disk file. The selection of Comm 1 or Comm 2 will send graphical results to the display devices connected to the personal computer communication (serial) ports.

Graphics Display Color Option:

```
ED Setup>Color

               Graphics Display Color Option

             A-Color
             B-B&W
```

Screen graphics may be in color or black/white (restrictive). Monitors that are not color should use B&W.

Graphics Hardcopy Color Option:

```
EE Setup>Color

               Graphics Hardcopy Color Option

             A-Color
             B-B&W
```

Hardcopy devices may present color or simply black/white images (restrictive).

Save Setup:

This selection saves the Machine-Specific Setup data in the binary file FSCBG.CFG. An < esc > returns to the Main Menu.

Files:

```
A Files

               Data File/Family Operations

             A-Open New or Old Data
             B-Save Current Data
             C-Import FSCBG 3.XX Data
```

Options A and B control selection of the Family Name. The user specifies a single unique name (up to eight characters) and FSCBG builds all data files from this Family Name by applying various extensions automatically:

- DAT For data files (containing input values and computed results; this file replaces input and restart files described in previous versions of FSCBG).

- DSP For dispersion files (containing dispersion results on the receptor grid).

- PRT For printer output files.

- Bxy For near-wake AGDISP output files, where xy = 01, 02, ... , 16 (replacing the FAGPLT files).

All data has been initialized with a set of default values from the Heather seed orchard study (Teske et al. 1991). An old data file may be opened (or a new one created) by selecting option "A"; FSCBG results may be saved with option "B". Data entry into FSCBG may be facilitated by the Data Input Sheet described in Section 11 of this manual.

Option "C" permits importing the contents of the complete filename (including extension) from earlier versions of FSCBG (this is the file created at Record 6.0 or input at Record 5.0 to run FSCBG 3.xx). In the import process FSCBG makes an attempt to interpret these old inputs. The user should always check this process. Old calculations will always have to be rerun.

An < esc > returns to the Main Menu.

Data Entry:

```
B Data

                Data Entry

             A-Run Title
             B-Model Selection
             C-Receptor Geometry
             D-Canopy Description
             E-Aircraft Description
             F-Spray System
             G-Spray Material
             H-Source Geometry
             I-Meteorological Data
```

Data input entry is accomplished in this menu.

The Run Title may be replaced by selecting "A". Model Selection specifies which of the FSCBG models are to be included in the present simulation. Receptor Geometry refers to points on or near the ground receiving spray material. Canopy Description refers to the size, shape, and density of vegetation receiving spray material. Aircraft Description describes the aerodynamic properties of the spray aircraft. Spray System gives the characteristics of the spray delivery system. Spray Material describes the physical properties of the spray material and spray drops. Source Geometry describes the spray path or flight lines followed by the spray aircraft, and the spraying speed. Meteorological data is the ambient weather data.

Model Selection:

```
BB Data>Model

                Model Selection                     Status

              A-Aircraft Wake                       Near Wake
              B-Evaporation                         yes
              C-Canopy                              Story Canopy
              D-Dosage                              no
              E-Concentration                       no
              F-Deposition                          yes
```

Model selection may be made in this menu. By selecting "A", the user will enter the Aircraft Wake Menu.

Aircraft Wake:

```
BBA Data>Model>Wake Model

                Wake Model

              A-none
              B-Wake Settling
              C-Near Wake
```

with the three options:

1. None - the aircraft wake does not influence drop trajectories.

2. Wake Settling - the SIMPLIFIED WAKE model of previous versions of FSCBG, depending on the aircraft weight, wing span or rotor diameter, and spraying speed.

3. Near Wake - the COMPLEX WAKE (AGDISP) model of previous versions of FSCBG, requiring detailed information about the spray aircraft.

Evaporation, Dosage, Concentration, Deposition:

```
BBB Data>Model>Yes/No

                Yes or No

              A-No
              B-Yes
```

where the path line indicates that Evaporation was selected in the Model Selection menu.

Canopy:

```
BBC Data>Model>Can Model

              Canopy Model

            A-none
            B-Story Canopy
            C-LiCor Canopy
```

with the three options:

1. None - no canopy.

2. Story Canopy - the canopy is described by stems/area.

3. LiCor Canopy - the canopy is described by emission level.

Evaporation specifies that spray drops are to be evaporated and/or drop evaporation curves (drop size versus time) are to be specified. Canopy specifies that spray drops are falling into a vegetative canopy (trees, shrubs, crops, etc.). FSCBG calculates the fraction of material reaching each layer of the canopy height, as well as the ground. Detailed canopy information is required for this option. Dosage, Concentration and/or Deposition specify dispersion of the spray material after it attains equilibrium with atmospheric conditions. Dosage, Concentration and Deposition can be calculated at any height below the release height, with or without a canopy. Near-wake results are calculated only at the top of the canopy or the ground (if no canopy).

When models have been selected, < esc > returns the user back to Data entry to permit access to each phase of data entry into FSCBG. If particular models are not selected (for instance Canopy), then line D in Data entry will be lower case and inaccessible to the user.

Receptor Geometry:

```
BC Data>Recep

               Receptor Geometry

             A-Receptor Grid
             B-Discrete Receptor(s)                  1
             c-Receptor Library
```

Receptor Grid permits access to the X and Y receptor locations; Discrete Receptors selects specific locations. The Receptor Library (a compendium of previous receptor grids that may be used as the starting point for modifications in a new problem) is not accessible.

Receptor Grid:

```
BCA Data>Recep>Grid

               Receptor Grid

             A-Grid Orientation                        .0 deg
             B-Grid Height(s)                           1
             C-Grid X Location(s)                      17
             D-Grid Y Location(s)                      25
             E-Create Regular Grid
```

Grid orientation angle refers to the orientation of the entered receptor grid to North. Grid Height(s) are the vertical position(s) of the grid. Grid X and Y Location(s) give the number of grid points in each direction. Option E permits the creation of a regularly spaced grid. A maximum of three Grid Heights, 100 Grid X Locations and 100 Grid Y Locations may be entered into FSCBG.

The units shown are the current default units for the input variables. In general, data may be entered in any acceptable units. The only requirement is that one blank space separates the data value from the data units. Units are generally abbreviated, and may take some getting used to; FSCBG will always provide the variety of units available for the selected variable when the user enters a space followed by a question mark (? < return >). All single valued data may be modified by selecting the menu line and entering the new value. Unlike previous versions of FSCBG, new entered values become the default.

Table 1 summarizes all units and abbreviations.

Grid Height(s):

```
BCAB Data>Recep>Grid>Grid Z

                          Receptor Grid Height(s)

                              Item   Location
                                        m
                                 1         .0
                               ---
                                 1
```

Tables in FSCBG may be scanned by pressing the cursor arrow keys. A maximum of ten table entries are shown on the screen at a time, although the total entries in the table is always given. If a specific entry is to be modified, the user would move to that line and < return >. The data entry would become the new value. The information line for a table contains three additional options:

A - to add a line to the table. This option does not depend on the position of the highlight bar since table entries are repositioned by FSCBG (from low to high value) after an add occurs.

D - to delete the data at the highlight bar (the current line).

G - to move the highlight bar to a specified line number, then < return > to replace the table entry (with repositioning).

Grid X and Y Location(s):

```
BCAC Data>Recep>Grid>Grid X

                          Receptor Grid X Value(s)

                              Item   Location
                                        m
                                 1     -54.90
                                 2     -36.60
                                 3     -18.30
                                 4         .0
                                 5      18.30
                                 6      36.60
                                 7      54.90
                                 8      73.20
                                 9      91.50
                                10     109.80
                               ---
                                17
```

BCAD Data>Recep>Grid>Grid Y

Receptor Grid Y Value(s)

Item	Location
	m
1	-109.80
2	-100.65
3	-91.50
4	-82.35
5	-73.20
6	-64.05
7	-54.90
8	-45.75
9	-36.60
10	-27.45

25	

Create Regular Grid:

BCAE Data>Recep>Grid>Reg Grid

Create Regularly Spaced Grid

A-Starting Grid X Location	-54.90 m
B-Grid X Spacing	18.30 m
C-Number of X Grid Locations	17
D-Starting Grid Y Location	-109.80 m
E-Grid Y Spacing	9.15 m
F-Number of Y Grid Locations	25
G-Create This Grid and Go Back	

This menu generates a new X and Y receptor grid system, replacing all previous values. After the user establishes the parameters for the grid generation, line G is selected to invoke the changes. Unlike most menus in FSCBG, if line G is not invoked, default data will not be changed.

Discrete Receptor(s):

BCB Data>Recep>Disc

Discrete Receptor Location(s)

Item	X	Y	Height
	m	m	m
1	100.00	.0	.0

This menu controls the placement of discrete receptors in the X, Y and Z (or height) directions. Horizontal movement in the table is

accomplished with the cursor arrow keys (left and right). A maximum of 100 Discrete Receptors may be entered into FSCBG.

Story Canopy Description:

```
BD Data>Canopy

                Canopy-Related Data

              A-Tallest Story
              B-Middle Story
              c-Smallest Story
              d-Canopy Library
```

FSCBG permits three different story canopies to exist simultaneously in the simulation. These are reached by the total height of the canopy story. If no canopies yet exist, only "A" will be upper case; if one canopy exists, "B" will also be upper case; and if two or three canopies are specified, "C" will also be upper case. The Canopy Library will contain a data base of characteristics for typical tree and crop canopies.

The Monte Carlo canopy penetration technique included in previous versions of FSCBG has been removed from this version. The only canopy solution technique is the Analytical Canopy approach.

Any Story:

```
BDA Data>Canopy>Char

                Tallest Canopy Characteristics

              A-Height of Story                  15.00 m
              B-Stand Density                    25.00 st/ac
              C-Probability of Penetration       .3800
              D-Element Size                      3.00 cm
              E-Tree Envelope                        9
```

Stand density specifies the number of plants per area. Penetration probability is the probability a droplet will pass completely through the horizontal dimension of an individual plant, expressed as a fraction from 0 (a tree that intercepts nothing) to 1 (a tree that stops the most it can). Element size is the width (diameter) of a representative vegetative element (leaf, stem, needles, etc.) of an individual plant.

Height of Story is set to 0 to remove the story.

Tree Envelope:

```
BDAE Data>Canopy>Char>Tree Env
```

Tallest Tree Envelope

Level	Height m	Diameter m
1	1.50	4.70
2	3.00	5.80
3	4.50	6.00
4	6.00	5.80
5	7.50	5.10
6	9.00	4.40
7	10.50	3.10
8	12.00	2.90
9	13.50	1.40

The average diameter as a function of canopy height is entered in this menu. A maximum of 20 Levels may be entered into FSCBG.

LiCor Canopy Description:

```
BD Data>LiCor Can
```

LiCor Canopy Data

A-Height of Foliage	15.00 m
B-Element Size	3.00 cm
C-LiCor Measurements	
D-Leaf Area Density	9

FSCBG also permits a canopy description based on data collected from the LiCor instrument. In this case the canopy is described by one set of emission levels.

LiCor Measurements:

```
BDC Data>LiCor Can>Meas
```

LiCor Canopy Measurements

A- 7 Degrees	.6480
B-23 Degrees	.6220
C-38 Degrees	.5460
D-53 Degrees	.4340
E-68 Degrees	.2700

The LiCor instrument is preset to five scan angles (from the vertical). The instrument records light hitting a fish-eye; usually, several measurements are taken within the canopy (and outside it) to quantify the effect of the vegetation.

Leaf Area Density:

```
BDD Data>LiCor Can>LAD
```

Leaf Area Density

Level	Height m	L.A.D.
1	1.50	1.00
2	3.00	1.00
3	4.50	1.00
4	6.00	1.00
5	7.50	1.00
6	9.00	1.00
7	10.50	1.00
8	12.00	1.00
9	13.50	1.00

Leaf Area Density, as defined here, gives an indication of the leaf surface area as a function of height through the foliage. FSCBG uses this table to compute a normalized integrated function that does not depend on the units assigned to Leaf Area Density (as long as entries are consistent). The defaults of 1 through the canopy implies that emission level is linear.

Aircraft Description:

```
BE Data>Aircraft

          Aircraft

        A-Type                                  Helicopter
        B-Name                                  Bell 47G3B2
        C-Description
        D-Aircraft Library
```

The spray aircraft is specified by Type, Name (user-supplied string), Description, or access to the Aircraft Library which contains characteristics for all aircraft described in Hardy 1987.

Type:

```
BEA Data>Aircraft>Type

               Aircraft Type

             A-Biplane
             B-Helicopter
             C-Fixed-Wing Propeller
             D-Jet
```

One of the four standard types is selected. The selection of wide-body aircraft has been removed in this version of FSCBG. Any of the four aircraft selections will configure the Description menu accordingly.

Description:

FSCBG default characteristics are for a helicopter, giving:

```
BEC Data>Aircraft>Helicopter

               Helicopter Description

             A-Weight                              1100.00 kg
             B-Rotor Diameter                        11.40 m
             C-Blade RPM                            350.00
```

If the default Type is changed to the other varieties, the results are:

```
BEC Data>Aircraft>Biplane

               Biplane Description

             A-Weight                              1100.00 kg
             B-Wingspan                              11.40 m
             C-Vert Distance Between Wings            1.50 m
             D-Planform Area                         34.09 sq m
             E-Drag Coefficient                      .1000
             F-Propeller Radius                       1.37 m
             G-Propeller Efficiency                  .8000
             H-Blade RPM                            350.00
             I-Engine Location(s)                        1
```

```
BEC Data>Aircraft>Fixed-wing prop

               Fixed-Wing Propeller Description

             A-Weight                                  1100.00 kg
             B-Wingspan                                  11.40 m
             C-Planform Area                             34.09 sq m
             D-Drag Coefficient                          .1000
             E-Propeller Radius                           1.37 m
             F-Propeller Efficiency                      .8000
             G-Blade RPM                                350.00
             H-Engine Location(s)                            1

BEC Data>Aircraft>Jet

               Jet Description

             A-Weight                                  1100.00 kg
             B-Wingspan                                  11.40 m
             C-Jet Exit Radius                            1.37 m
             D-Jet Thrust                              3264.00 kg
             E-Engine Location(s)                            1
```

Because the same variables hold the default values, all aircraft have the same weight as the helicopter, have propeller RPMs equal to the helicopter rotor blade RPM, have biplane and propeller aircraft characteristics the same, and have propeller radius and jet exit radius identical. Access to the Aircraft Library eliminates confusion caused by this simplification.

The inclusion of Vertical Distance Between Wings separates the Biplane from the Fixed-Wing Propeller aircraft. The Wingspan of the Biplane (the upper wing) has been eliminated from the input in this version of FSCBG.

Engine Location(s):

```
BECI Data>Aircraft>Biplane>Engine Loc

               Engine Location(s)

             A-Engine Forward Location(s)               .0 m
             B-Engine Horiz/Vert Location(s)             1
```

Non-helicopter aircraft description must include the location of the propeller(s) or jet engine(s). The first entry in this menu locates the position of the engine(s) relative to the back (trailing) edge of the wing of the aircraft. Positive values are measured forward toward the nose of the

aircraft. The position of the propeller hub(s) and the exit of the jet engine(s) are the reference location points.

Engine Horizontal and Vertical Location(s):

```
BECIB Data>Aircraft>Biplane>Engine Loc>Horiz/Vert

                        Horiz/Vert Engine Location(s)

                       Engine Horizontal   Vertical
                                  m           m
                           1         .0        .3700
```

Table entry specifies the location of the powerplant horizontally (from the center of the aircraft, positive measured to the right of the pilot, and vertically (from the nominal height of the wing, positive measured upward to the engine). A maximum of four engines may be entered into FSCBG.

Only rectangular fully rolled up vortices are supported in the present version of FSCBG. Betz roll up, triangular fully rolled up vortices, and external Wake file options have been removed. FSCBG always computes vortex strength as a part of its calculation process.

In Wake Settling only Weight and Wingspan (or Rotor Diameter) are accessible to the user.

Aircraft Library:

```
BED Data>Aircraft>Library

                        Aircraft Library
```

FSCBG contains an aircraft library whose default values include all available data from Hardy 1987 (currently 109 entries). These data are arranged in alphabetical order by aircraft, with 15 entries displayed on the screen at a time. The cursor keys may be used to move up or down in the list, and page up/down or the left and right cursor keys to move up or down 15 entries at a time. When the desired aircraft is highlighted, < return > displays the retrieved aircraft values. For example, for the Aerospatiale Puma, the data are:

```
                Retrieve Aircraft Library Entry

Name                                Aerospatiale Puma
Type                                Helicopter
Weight                                 5585.37 kg
Rotor Diameter                           15.00 m
Blade RPM                               265.00
Typical Flying Speed                     68.87 m/s
```

all displayed in current units. Other aircraft types will include all the needed data to initialize the aircraft type. At this point < return > selects this data and leads to:

```
                Confirm Use Library Entry

              A-No
              B-Yes

          Answering "Yes" will overwrite current
          data with that of the library entry
```

Option B moves the data into current values; < esc > prevents this step. Typical Flying Speed is shown but is NOT transferred back to Spraying Speed.

The Aircraft Library will also permit adding and deleting entries, to customize its contents.

Spray System:

```
BF Data>Spray Sys

                Spray System

              A-Nozzle Forward Location(s)          .0 m
              B-Nozzle Horiz/Vert Location(s)       17
              c-Spray System Library
```

This menu isolates the nozzle geometry from the aircraft characteristics so that specific nozzle configurations may be saved separately from aircraft in the Spray System Library. The first entry in this menu locates the position of the nozzles relative to the trailing edge of the wing of the aircraft (fixed wing) or relative to the shaft centerline (helicopter). Positive values are measured forward toward the nose of the aircraft.

Nozzle Horizontal and Vertical Location(s):

BFB Data>Spray Sys>Horiz/Vert

Horiz/Vert Nozzle Location(s)

Nozzle	Horizontal m	Vertical m
1	-4.31	-2.46
2	-3.73	-2.46
3	-3.25	-2.46
4	-2.76	-2.46
5	-2.28	-2.46
6	-1.79	-2.46
7	-1.30	-2.46
8	-.6500	-2.46
9	.0	-2.46
10	.6500	-2.46

Table entry specifies the location of the nozzles horizontally (from the center of the aircraft, measured positive to the right of the pilot), and vertically (from the nominal height of the wing or the helicopter rotor plane, measured positive upward to the nozzles). The Vertical locations on a helicopter should always be negative (spray boom below the rotor blade). A maximum of 20 Nozzle Locations may be entered into FSCBG.

Spray Material:

BG Data>Spray Mat

Spray Material

A-Material Half-Life	Infinite
B-Density of Carrier	.9970 g/cm3
C-Carrier Type	water
D-Volatile Fraction of Carrier	.9400
E-Mass Size Distribution	
F-Minimum Drop Diameter	5.00 mic
g-Physical Constants	
h-Spray Material Library	

Specifics about the released spray material are entered in this menu. Material half-life is used to calculate the exponential decay of material due to chemical and/or physical processes other than evaporation. A value of 1.0E+30 results in no decay, or INFINITE as displayed in the menu. This parameter should be changed only when very specific information is known about the drop material.

Carrier Type:

```
BGC Data>Spray Mat>Carrier

               Carrier Type Specification

             A-Non-Water
             B-Water
             C-Quadratic Equations
```

A Non-Water carrier will require entry of Physical Constants. Specification of evaporation by Quadratic Equations removes the need to solve for the evaporation details, but requires evaporation data.

Volatile Fraction of Carrier is that mass or volume fraction (0 to 1) that may potentially evaporate. All drops with diameters below the Minimum Drop Diameter are treated as gaseous material. Minimum Drop Diameter should be changed only when very specific information is known about the drop material.

The Physical Constants menu will be activated for Non-Water spray material. A Spray Material Library will recover all of this information.

Mass Size Distribution:

```
BGE Data>Spray Mat>Mass Size Dist

               Mass Size Distribution

             A-Specification                 average diameter
             B-Mass Size Distribution                11
             C-Mass Size Distribution Library


BGEA Data>Spray Mat>Mass Size Dist>Spec

               Mass Size Distribution Specification

             A-Upper Diameter
             B-Average Diameter
```

Three specifications of Mass Size Distribution are available. A maximum of 16 drop size divisions may be entered into FSCBG.

Upper Diameters:

```
BGEB Data>Spray Mat>Mass Size Dist>Up Diam
```

Drop Diameter Upper Diameters

Category	Upper Diam mic	Mass Fraction
1	667.00	.2490E-01
2	742.00	.7830E-01
3	840.00	.9540E-01
4	1020.00	.1156
5	1420.00	.1201
---		----------
5		.4343

Upper Diameters give the upper diameter on each size class, with the lower diameter being the previous size class upper diameter (the first upper diameter has a lower diameter of 0). Mass fraction is the fraction of material found in each size category (the total mass fraction is less than or equal to 1).

Average Diameters:

```
BGEB Data>Spray Mat>Mass Size Dist>Avg Diam
```

Drop Diameter Average Diameters

Category	Avg Diam mic	Mass Fraction
1	106.40	.2490E-01
2	138.60	.7830E-01
3	171.00	.9540E-01
4	203.40	.1156
5	235.90	.1201
6	268.30	.1115
7	301.30	.1119
8	334.80	.1009
9	366.70	.7140E-01
10	398.20	.5660E-01
---		----------
11		.9304

Average Diameters specify the diameter best representative of each size class. If computations have been made with SDC (Teske 1989) then the volume-average diameter suggested by Herdan 1960 has been used to determine average diameter.

Quadratic Equations:

```
BGE Data>Spray Mat>Quadratic
```

Drop Diameter Quadratic Equation Coefficients

Category	coef A mic	B (/sec) mic	C (/sec2) mic	Mass Fraction
1	400.00	-2.59	-.1660E-01	.2490E-01

				.2490E-01

Quadratic Equations coefficients specify the evaporation effect on each drop size in the distribution, following the formula

$$\text{Drop Size} = A + B\,t + C\,t^2$$

with the coefficients A, B and C different for every size class, and generally determined by careful laboratory tests. Only one set of quadratic coefficients may be entered in the present version of FSCBG; previous versions permitted two sets of coefficients.

Mass Size Distribution Library:

```
BGEC Data>Spray Mat>Mass Size Dist>Library
```

Mass Size Distribution Library

FSCBG contains a mass size distribution library whose default values include all available data from Skyler and Barry 1990 (currently 243 entries). These data are arranged in alphabetical order first by nozzle type and then by spray material. The cursor keys and page up/down control movement through the list. When the desired mass size distribution is highlighted, < return > displays the saved distribution values. For example, for the 8004 Flat Fan nozzle spraying Water and oriented 90 deg (vertically downward) in a 100 mph airstream, the data are:

Retrieve Mass Size Library Entry

8004 Flat Fan		Water	90 deg 100 mph
Upper Dia (mic)	Mass Fraction	Upper Dia (mic)	Mass Fraction
56.00	.1170E-01	382.00	.5620E-01
89.00	.2420E-01	414.00	.2820E-01
122.00	.4050E-01	447.00	.1890E-01
154.00	.1041	479.00	.1600E-01
187.00	.1285		
219.00	.1158		
252.00	.1092		
284.00	.1352		
318.00	.1224		
351.00	.8240E-01		

displayed in current diameter units. If the original distribution (in Skyler and Barry 1990) contained more than 16 drop sizes, all drop sizes were paired, with mass fraction below 0.01 dropped at the higher diameters. Upper Diameters are presented here so that further combining may be done easily. At this point < return > moves to confirm as with the Aircraft Library.

The Mass Size Distribution Library will also permit adding and deleting entries, to customize its contents.

Physical Constants:

```
BGG Data>Spray Mat>Phys Cons

          Physical Constants

        A-Molecular Weight                  18.01 g/mol
        B-Diffusivity                        none cm2/s
        C-Latent Heat of Vaporization        none cal/g
        D-Molal Concentration                none mol/cm3
        E-Ambient Vapor Pressure             none mb
        F-Thermal Conductivity               none cal/deg k_cm_s
        G-Vapor Pressure Coefficient B       3.00 ln mb
        H-Vapor Pressure Coefficient C     258.55 (ln mb)_deg k
```

This menu is entered for nonwater spray material. The default shown for Molecular Weight is water (in grams per mole). If no entries are made for options B to F (retaining "none" for Diffusivity in square centimeters per second, Latent Heat of Vaporization in calories per gram, Molal Concentration in moles per cubic centimeters, Ambient Vapor Pressure in millibars, or Thermal Conductivity in calories per degrees Kelvin per centimeter per second), FSCBG assumes the uninitialized

properties are water-like and computes their values. Unlike other menus in FSCBG, units may not be substituted here. Standard physical properties reference books (such as Lyman, Reehl and Rosenblatt 1990) may be consulted for these properties. The typical FSCBG user should be cautioned when entering nonwater spray material descriptors.

The Vapor Pressure Coefficients B and C describe the vapor pressure variation with the formula

$$\ln(\text{Vapor Pressure}) = B + C / T$$

where T is the temperature of the drop. B and C may be inferred from tables (Weast 1981) with appropriate manipulation into the required units. The default values shown in the Physical Constants Menu have been deduced from atmospheric characteristics at the Heather site.

Source Geometry:

```
BH Data>Src Geom

               Source Geometry

             A-Spraying Speed                        17.90 m/s
             B-Release Height                        23.60 m
             C-Emission Rate                          5.00 gal/ac
             D-Swath Width                           18.30 m
             E-Source Location(s)                        9
             F-Add Regularly Spaced Sources
             g-Source Geometry Library
```

Flight line information is entered in this menu. Spraying Speed is the flight speed of the aircraft. Release Height is the height above the ground of the helicopter rotor plane, or the nominal height of the main wing of a fixed-wing aircraft, or the height of the spray nozzles for stationary or ground vehicle spray systems.

The Source Geometry Library will save typical spray flight line geometries.

When Emission Rate is entered as amount of material released per area, an additional length, Swath Width, must also be specified. In these cases the "D" entry will be upper case. Swath Width is normally the distance between adjacent spray lines. Emission Rate is the total system flow rate through all of the nozzles combined.

Source Location(s):

BHE Data>Src Geom>Source Loc

Source Line Location(s)

Line	X begin m	Y begin m	X end m	Y end m
1	.0	-73.20	183.00	-73.20
2	.0	-54.90	183.00	-54.90
3	.0	-36.60	183.00	-36.60
4	.0	-18.30	183.00	-18.30
5	.0	.0	183.00	.0
6	.0	18.30	183.00	18.30
7	.0	36.60	183.00	36.60
8	.0	54.90	183.00	54.90
9	.0	73.20	183.00	73.20

Each spray line is described by the X and Y coordinates of the start and end of the line, relative to the grid system origin. "Begin" points are the locations at which the spray is turned on, and "End" points are the locations at which the spray is turned off. In all cases flight lines must be parallel to each other and the aircraft must fly in the same direction. Serpentine calculations are achieved by combining the results of two FSCBG calculations. A maximum of 100 spray lines may be entered into FSCBG.

Add Regularly Spaced Sources:

BHF Data>Src Geom>Add Reg

Add Regularly Spaced Sources

A-Start X of 1st Source	.0 m
B-Start Y of 1st Source	91.50 m
C-End X of 1st Source	183.00 m
D-End Y of 1st Source	91.50 m
E-X Distance Between Sources	.0 m
F-Y Distance Between Sources	18.30 m
G-Number of Sources to be Added	1
H-Add the Sources and Go Back	

This menu will add additional X and Y source lines to those already in the calculation. After the user establishes the parameters for the source generation, line H is selected to invoke the addition. Unlike most menus in FSCBG, if line H is not selected, default data will not be changed.

Meteorological Data:

```
BI Data>Met

               Meteorological Data

             A-Vortex Decay Coefficient                 .5600 m/s
             B-Surface Pressure                       1013.00 mb
             C-Net Radiation Index                       1.00
             D-Open Terrain                                 8
             E-Within Canopy                                7
             F-Advanced Override Inputs
             g-Meteorological Data Library
```

Atmospheric data is entered in this menu. Vortex Decay Coefficient is an atmospheric parameter that influences the decay of aircraft vortices. When the entry has units of "const", it is interpreted by FSCBG as a nondimensional number. A value of 0 specifies no decay of the wing-tip vortices, and a value of 2 specifies a strong reduction of the wing-tip vortices due to a close proximity of the aircraft to the ground or the top of a canopy. Typical values may range from 0.41, for calculations without canopy or ground effect, to 1.8 with canopy or ground effect. A nominal value is 0.74.

When the value of Vortex Decay Coefficient has units of velocity, it is interpreted as the nondimensional constant times the ambient turbulence velocity. Field test experiments show a strong correlation with a value of 0.56 m/sec.

Net Radiation Index is a single parameter that reflects the position of the sun, cloud cover, and inversion height. It ranges in value from -2 to +4, and is determined by the procedure outlined in Table 2.

The Meteorological Data Library will recover saved atmospheric data.

Open Terrain or Within Canopy:

BID Data>Met>Open Terrain

Open Terrain Meteorology

Level	Height m	Temp deg c	% RH	Wind Speed m/s	Wind Dir deg
1	lavg	5.40	85.00	none	none
2	15.00	none	none	1.10	35.80
3	16.50	none	none	1.12	37.40
4	18.00	none	none	1.30	38.30
5	19.50	none	none	none	40.10
6	21.00	none	none	1.30	43.20
7	22.50	none	none	1.40	42.40
8	24.00	none	none	1.70	47.20

A typical meteorological table is given here. The first level is always "lavg" -- the Layer Average values (these are typical values assumed throughout the layer examined). Temperature, Relative Humidity, Wind Speed and Wind Direction may not exhibit layer average values and also values elsewhere in height. The "none" entry is entered by "n" as shown on the information line. Profiles specified with several height values do not have to have all height values; however, Height cannot have "none" anywhere. If none of the inputs are Layer Average, all four entries at Level 1 will be "none". A maximum of ten Heights plus lavg may be entered into FSCBG.

Advanced Override Inputs:

BIF Data>Met>AOI

Advanced Override Inputs

A-Wind Speed at 10 meters	none m/s
B-Power Law Coefficient	none
C-Azimuth Std Dev	none rad
D-Elevation Std Dev	none rad
E-Mixing Depth	none m
F-Averaging Time	600.00 sec
g-Source Depth	
h-Terrain Features	

FSCBG offers some added flexibility to enter specific field data for its meteorological input. The profile for Open Terrain Wind Speed may be specified by entering the value of the Wind Speed at 10 m, and the Power Law exponent. Azimuth and Elevation Standard Deviations give a measure of the horizontal and vertical atmospheric turbulence levels

typically computed over an Averaging Time of 10 min, with Wind Speed and Wind Direction data taken at 1 sec intervals. The Mixing Depth is the estimated thickness of the surface boundary layer. Source Depth is the assumed layer thickness for gaseous predictions.

TABLE 1. FSCBG Units Abbreviations

Type	Designation	Actual Units
Length	mic	microns
	mm	millimeters
	cm	centimeters
	m	meters
	km	kilometers
	in	inches
	ft	feet
	mi	miles
Area	sq mm	square millimeters
	sq cm	square centimeters
	sq m	square meters
	hect	hectares
	sq in	square inches
	sq ft	square feet
	ac	acres
Volume	cu mm	cubic millimeters
	cu cm	cubic centimeters
	cu m	cubic meters
	l	liters
	cu in	cubic inches
	cu ft	cubic feet
	ozf	fluid ounces
	gal	gallons
Mass	mg	milligrams
	g	grams
	kg	kilograms
	slug	slugs
	oz	ounces
	lb	pounds
Time	sec	seconds
	min	minutes
	hr	hours
	day	days
	yr	years

TABLE 1. FSCBG Units Abbreviations (continued)

Type	Designations	Actual Units
Temperature	deg c	degrees Centigrade
	deg f	degrees Fahrenheit
Pressure	mb	millibars
	in hg	inches of Mercury
	in h2o	inches of water
	pa	pascals
	psi	pounds per square inch
Speed	cm/s	centimeters per second
	m/s	meters per second
	kph	kilometers per hour
	ft/s	feet per second
	mph	miles per hour
	kts	knots
Angle	rad	radians
	deg	degrees
Force	nt	Newtons
	lb	pounds
	kg	kilograms
Density	g/cm3	grams per cubic centimeter
	kg/m3	kilograms per cubic meter
	lb/in3	pounds per cubic inches
	lb/ft3	pounds per cubic feet
Emission	g/m	grams per meter
	ozf/ft	fluid ounces per foot
	l/min	liters per minute
	gal/mn	gallons per minute
	l/hec	liters per hectare
	ozf/ac	fluid ounces per acre
	gal/ac	gallons per acre
Stand Density	st/ac	stems per acre
	st/hec	stems per hectare

TABLE 2. Net Radiation Index Computation

1. If the total cloud cover is 10/10 and the ceiling is less than 2133.6 m (7,000 ft), net radiation index equals 0 (day or night).

2. For nighttime (between sunset and sunrise): if total cloud cover is less than or equal to 4/10, net radiation index equals -2; otherwise net radiation index equals -1.

3. For daytime: first determine the net radiation index as a function of solar altitude from the following table:

Solar Altitude (Degrees of azimuth)	Insolation	Net Radiation Index
60 < A < 90	Strong	4
35 < A < 60	Moderate	3
15 < A < 35	Slight	2
0 < A < 15	Weak	1

Then, if total cloud cover is less than or equal to 5/10, net radiation index equals the table value; otherwise, modify net radiation index by following these steps:

a. Ceiling less than 2133.6 m (7000 ft), subtract 2.

b. Ceiling greater than or equal to 2133.6 m, but less than 4876.8 m (16,000 ft), subtract 1.

c. Total cloud cover is equal to 10/10, subtract 1. This will only apply to ceilings greater than or equal to 2133.6 m, since cases with 10/10 coverage below 2133.6 m are considered in step 1 above.

d. If net radiation index has not been modified by steps 1, 2, or 3 above, use unmodified net radiation index.

e. If modified net radiation index is less than 1, set it equal to 1.

5. CALCULATIONS

With inputs all entered into FSCBG, the user returns to the Main Menu and selects Calculations:

Calculations:

```
C Calc

                    Calculations

                 A-Do Calculations
                 B-Check Data Only
                 C-Force All Calculations
                 D-Print Inputs Only
                 E-Print Options
```

The standard procedure would be to Do Calculations. FSCBG determines internally which models should be run based on what the user has changed in the input portion of the program. Confusion over where to RESTART a run is eliminated, and, as a safety measure, the user may specify Force All Calculations to be sure (or to recover a complete run result in the printed output file, for example). In any of these cases Check Data Only will always be performed to check the validity of all input variables.

Do Calculations:

```
CA Calc>Start

            Do Calculations

            Meteorology
            Open Terrain Evaporation
            Within Canopy Evaporation
            Canopy Deposition
            Near Wake Trajectories
            Dispersion

            The calculation modules above are selected.
            Press <return> to begin calculating.
            Press <esc> to return to the calculations menu.
```

FSCBG displays the calculations that will be performed, and seeks validation of the procedure before beginning (calculations cannot be interrupted easily once they have started).

```
CA Calc>Start

                        COMPUTATION STATUS
                      Checking Input Variables

  Level  Variable Description  Minimum  Value  Maximum  Units

 *warning*
 **error**

          __ error(s)          __ warnings(s)
```

FSCBG then checks the input data (this menu is also entered directly with option B). All inputs to FSCBG have minimum and maximum value ranges. FSCBG also traps all incorrect entries (such as "none" when there should be a value). If a variable value is outside liberal limits on its magnitude, an error or warning message will be displayed. Some variables cannot go beyond certain limits; these generate errors (such as a negative spraying speed). The offending variables are defined by name and then acceptable limits are shown, along with the entered value. If values are required where "none" is specified, the explanation "value missing" will be displayed. Also, in the meteorological tables, no height may be "none"; every height must have at least one entry of temperature, relative humidity, wind speed or wind direction; every entry must be defined at at least one height; and a Layer Average entry may not also have an entry at a height (resulting in "lavg conflict"). Other messages are the following:

Canopy Meteorology - A value for temperature, relative humidity, wind speed or wind direction was not entered for canopy meteorology
Invalid Family Name - FSCBG cannot proceed to calculations without a valid Family Name
Missing Canopy - The canopy option has been invoked, but a canopy has not been entered
Missing Canopy Meteorology - Canopy meteorological data has not been entered
Missing Dispersion Flag(s) - None of dosage, concentration or deposition was selected
Missing Drop Size Distribution - A drop size distribution has not been entered
Missing Engine(s) - The selected aircraft type requires propeller or jet engines
Missing Nozzle(s) - Nozzle locations have not been entered
Missing Open Meteorology - Open meteorological data has not been entered
Missing Receptor Grid - No receptor grid has been established

Missing Run Title - the run has not been identified
Missing Spray Source Line(s) - Spray lines have not been entered
Missing Tree Envelope - Within a canopy the tree shape has not been entered
Near Wake Print Interval - Near wake trajectory results must be printed at positive intervals
No Wake Model Invoked - The wake model selected was "none"
Open Meteorology - A value for temperature, relative humidity, wind speed or wind direction was not entered for open meteorology
Source Line Outside Grid - One or more source lines are not directly over the receptor grid
Source Lines Not Parallel - All source lines must be parallel to each other
Source Lines Not Racetrack - All source lines must be flown in the same direction by the aircraft
Total Mass Fraction - Total mass fraction from all drop sizes should be less than or equal to 1.0

Warnings may be overridden and calculations performed; errors may not. If no errors or warnings exist, the Checking Input Variables Status Table will appear only briefly.

Print Inputs Only writes the input data into an ASCII-readable file with the Family Name and the extension PRT. The user may then type this file to the screen, or print it on an attached dot-matrix (or other) printer. Output is constrained to 80 columns for observation by the user with the DOS command MORE.

Print Options:

```
CE Calc>Prt Opts

               Print Options

             A-Evaporation Model Detail          no
             B-Evaporation Regression Coeff      no
             C-Canopy Model Scavenging Detail    no
             D-Near Wake Trajectory Detail       no
             E-Near Wake Model Summary           no
```

Option A prints the details of the evaporation formula integration for each drop size; option B summarizes the quadratic equation curve fits to the integration results; option C prints the details of canopy scavenging; option D prints the details of the trajectory integration for each drop size; and option E summarizes the deposition of the trajectories at the top of the

canopy (if a canopy exists) or on the ground (with no canopy specified). The dispersion calculation does not produce any printed output.

```
CEA Calc>Prt Opts>Evap Detail

               Print Evaporation Model Detail

             A-no
             B-Open Terrain Only
             C-Within Canopy Only
             D-both
```

This menu permits the selection of where to print details of the Evaporation solution. A selection of "both" includes Open Terrain and Within Canopy (if canopy is present).

The same menu appears for Print Evaporation Regression Coefficients. Canopy Model Scavenging Detail is a yes/no menu. Near Wake Trajectory Detail requires an integer entry. This becomes the interval between printouts of the trajectory solution (typical value = 10). An entry of 0 turns off the trajectory detail and recovers "no". Near Wake Model Summary is a yes/no menu.

Print Options contains all optional outputs from FSCBG. FSCBG always computes and saves mass, drops, NMD and VMD, to permit the user full access to whatever post-calculation graphics are invoked. The Near Wake trajectory files are also always produced.

Because of the Family Name concept, the user should save results in a new Family Name whenever changes have been made to the inputs. Otherwise, any invoked calculations will write over previously obtained results. Disk file management is now even more important than before, since the old FAGPLT limit of 100 files is discarded, and the program does not spend much time worrying about how much disk space it is taking up.

Once calculations begin, the possible Status Tables are as follows:

```
                    Meteorology
```

When computing the essential curve fits to wind speed, wind direction, temperature and relative humidity.

Evaporation

```
Open Terrain
   Evaporation Parameters
   Drop Category (__ Total):
   Drop Diameter:
   Simulation Time:
   Regression Analysis
```

When computing the data needed for the regression curve fits. This module is invoked even if evaporation is not. Evaporation parameters are first computed; then, as integration of the drop diameter equations proceed, the screen updates the drop size category number, the drop diameter and the simulation time. The regression curve fits are then determined. If a canopy is present, a similar calculation is also made for Within Canopy.

Canopy

When computing the canopy scavenging with the analytic canopy penetration model. This model has been improved by replacing the previous impaction formulation with the cylindrical data from Golovin and Putnam 1962, and the interception data from Pulley and Walters 1990.

Near Wake Trajectories

```
Open Terrain
   Drop Category (__ Total):
   Drop Diameter:
   Simulation Time:
   Lagrangian Equations (__ Total):
```

When computing the Lagrangian trajectory solution for each nozzle in the simulation, following Teske 1990. As integration of the trajectory equations proceeds, the screen updates the drop size category number, the drop diameter, the simulation time and the number of active equation sets. Unlike previous version of FSCBG, the current version uses the curve fits to the wind speed and direction data to generate the wind components to this version of AGDISP, and uses the quadratic curves to the drop diameter for evaporation effects. All results are saved in binary files with the Family Name and extensions of B01, B02, ... B16 as needed.

Dispersion

```
Initialization
Receptors
   Flight Lines (__ Total):
   Nozzle Number (__ Total):
   Drop Category (__ Total):
   Percent Completed: __ percent
```

When computing the gaussian dispersion solution for dosage, concentration and deposition. As calculation proceeds, the screen updates the flight line number, nozzle number, drop size category numbers, and computes a percent completed value. All results are saved in a dispersion file with the Fanily Name and extension DSP.

Printed Output:

All printed output is contained in 80 column format to make it easily observable by the user with the DOS command

TYPE filename.PRT|MORE

filling the screen each time a key is pressed.

The first part of every print file is the Inputs section, reviewing all inputs to FSCBG in the units prescribed by the user. These sections include:

MODELS SELECTED
RECEPTOR GRID GEOMETRY
DISCRETE RECEPTOR GEOMETRY
AIRCRAFT
SPRAY SYSTEM GEOMETRY
SPRAY MATERIAL
SOURCE GEOMETRY
METEOROLOGY

The rest of the output is user-selected in the Print Options Menu (path CE) and in the plot options. These include:

COMPUTED METEOROLOGICAL AVERAGES

Giving the average wind speed, wind direction (the direction the wind is blowing from), and the wind speed shear above the canopy or open terrain, and the average temperature and relative humidity. The computed

standard deviations (horizontal and vertical) and the mixing layer depth are also displayed.

COMPUTED EVAPORATION PARAMETERS

Giving the evaporation model details: Ambient Vapor Pressure, computed Air Density, Molal Concentration, Latent Heat of Vaporization, Diffusivity and Thermal Conductivity (these values may appear in the Inputs section if the drop fluid is nonwater and the user enters any or all of these parameters). The Pressure and Temperature at the surface of the drop are also displayed, along with the computed Absolute Viscosity.

There follows an Evaporation Details table for each Drop Diameter, including columns for:

Drop Height - From release point (or canopy top) to surface impact
Average Diameter - Drop size as it evaporates
Fall Time - Simulation time of the calculation
Downwind Distance - Horizontal position of the drop (due to the wind direction)
Settling Velocity - Fall velocity of the drop due to gravity
Fraction Material Remaining - Amount of material still in the drop

There follows a Regression Coefficients table for each Drop Diameter, including quadratic coefficients A, B and C in the formula:

$$\text{Variable} = A + B\,X + C\,X^2$$

where Variable is the dependent variable and X is the independent variable. The first three columns display A, B and C respectively; the fourth and fifth columns give the limits of applicability on the independent variable. Above the canopy (or open terrain), Regression Coefficients are developed for:

Settling Velocity as a function of Downwind Distance
Drop Height as a function of Downwind Distance
Fraction Material Remaining as a function of Drop Height
Fall Time as a function of Drop Height
Average Distance as a function of Drop Height
Average Distance as a function of Fall Time

Within the canopy, Regression Coefficients are developed for:

Settling Velocity as a function of Drop Height
Drop Height as a function of Downwind Distance
Downwind Distance as a function of Drop Height
Fraction Material Remaining as a function of Drop Height
Average Diameter as a function of Drop Height
Average Diameter as a function of Fall Time

COMPUTED CANOPY SCAVENGING

Giving the Fraction Material Remaining through the canopy as a function of Drop Height for each Drop Diameter, and the Mass Averaged Fraction Material Remaining for all drops.

NEAR WAKE COMPUTATIONS

Giving Trajectory Results for each Drop Diameter in the simulation. This table includes columns for:

Simulation Time
Horizontal and Vertical Locations of the drop
Horizontal and Vertical Velocities of the drop
Growth of Standard Deviation due to ambient turbulence.

There follows an Interception Summary for each Drop Diameter, giving:

Total Time from drop release from the nozzle to the top of the canopy (or ground if no canopy)
Horizontal and Vertical Locations of the drop at interception with the canopy (or ground)
Standard Deviation at interception
Fraction Material Remaining at interception

6. RESULTS

Before and after Calculations, the user may get to

```
D Results

                Results

              A-Preview Plots
              B-Meteorological Plots
              C-Evaporation Plots
              D-Canopy Plots
              E-Near Wake
              F-Dispersion
              g-Total Accountancy
```

for:

1. Previewing plots BEFORE calculations are performed.

2. Displaying plots of calculated results.

Preview Plots:

```
DA Results>Prev

                Preview Plots

              A-Receptor Grid and Flight Lines
              B-Nozzles and Engines
              C-Initial Mass Fraction
              D-Initial Cumulative Mass Frac
              E-Tree Envelope
              f-LiCor Inputs
```

Option A leads to:

```
DAA Results>Prev>View

                Select View

              A-Top View
              B-3D View
              C-B/T Elevation View
              D-L/R Elevation View
```

The Top View will present the user with a picture of the receptor grid and flight lines from above; 3D View will place them into perspective; B/T Elevation View will present the ground-level view from Bottom to Top of the Top View (low scale value to high scale value as viewed by an observer at the right edge of the computer screen); and L/R Elevation View will present the ground-level view from Left to Right of the Top View (low scale value to high scale value as viewed by an observer at the bottom edge of the computer screen).

Any of these five options will lead to:

```
DAAA Results>Prev>View>Grid/Fl Lines

               Receptor Grid and Flight Lines

             A-View Plot
             B-Hardcopy Plot
             C-Plot Format
```

where the options are:

1. View the plot on the screen.

2. Generate a hardcopy of the plot on an attached plotting device.

3. Modify the plot format.

Selection of View Plot will paint the plot to the computer screen. FSCBG continues by pressing any key.

Plot Format:

```
DAAAC Results>Prev>View>Grid/Fl Lines>Fmt

               Plot Format

             A-X Axis
             B-Y Axis
             C-Change Legend
             D-Margins

Current Plot Legend:
RECEPTOR GRID AND FLIGHT LINES
```

This menu permits the user to change the appearance of the plot on the output device by modifying the X and/or Y Axes, changing the Legend, or altering the Margins. For 3D View additional options are available:

```
DAABC Results>Prev>View>3D>Fmt

               3D Plot Format

             A-X Axis
             B-Y Axis
             C-Z Axis
             D-Viewing Angle
             E-Change Legend
             F-Margins
```

X or Y Axis:

```
DAAACA Results>Prev>View>Grid/Fl Lines>Fmt>X

               X Axis Options

             A-Tic Marks                              yes
             B-Tic Label Character Height           .1500
             C-Change Axis Label
             D-Axis Label Character Height          .1500
             E-Auto Scale Axis                        yes
             f-Scale Minimum
             g-Scale Maximum
             h-Scale Increment

X Axis Label:
WEST TO EAST DISTANCE (m     )
```

These options perform the following:

1. Remove tic marks.

2. Change the size of scale labels.

3. Change the axis label.

4. Change the size of the axis label.

5. Scale the axis internally (autoscale) or user-controlled.

Margins:

```
DAAACD Results>Prev>View>Grid/Fl Lines>Fmt>Mrgn

               Plot Margins

             A-Left Margin                              1.50
             B-Right Margin                             1.00
             C-Top Margin                              .5000
             D-Bottom Margin                            2.00
```

These entries restrict the plotting area of the device (not including scales and labels) left and right, top and bottom.

The 3D View Plot Format also includes:

Z Axis:

```
DAABCC Results>Prev>View>3D>Fmt>Z

               Z Axis Options

             A-Auto Z Factor                             yes
             b-Z Factor
```

Option A allows the program to scale the Z axis so that all data is displayed. By setting Option A to "no", the Z Factor may be adjusted for personal preference (a value of 1.0 recovers the autoscaled value).

Viewing Angle:

```
DAABCD Results>Prev>View>3D>Fmt>View Ang

               Select 3D Viewing Angle

             A-Z Rotation                         -20.00 deg
             B-X Rotation                         -60.00 deg
```

This option presents the rotation of the 3D View to practically any configuration, even confusing ones (the defaults shown here may be re-entered if the user becomes totally lost). The first rotation is about the Z (straight out of the screen) axis in the Top View. Negative rotation is clockwise. The second rotation is about the X (horizontal) axis in the nonrotated Top View. Negative rotation rotates the view toward the horizontal.

The Tree Envelope option includes an additional option:

```
DAEC Results>Prev>Tree Env>What

               What to Include in Tree Envelope Plot

             A-Tallest Story Tree Envelope
             b-Middle Story Tree Envelope
             c-Smallest Story Tree Envelope
```

to select which tree canopy to plot.

The LiCor Inputs option includes two plot options:

```
DAF Results>Prev>LiCor

               LiCor Preview Plots

             A-LiCor Measurements
             B-Leaf Area Density
```

to plot either of the entered tables of information.

Post-Calculation Plot options include the following:

```
DB Results>Met

               Meteorological Plots

             A-Wind Speed vs Height
             B-Relative Humidity vs Height
             C-Temperature vs Height
             D-Wind Direction vs Height

DC Results>Evap

               Evaporation Plots

             A-Select Drop Category for Plots         1
             B-Select Time for Mass Fraction         .0 sec
             C-Material Fraction vs Height
             D-Downwind Distance vs Height
             E-Settling Velocity vs Height
             F-Drop Diameter vs Height
             G-Drop Diameter vs Time
             H-Mass Fraction at Time
             I-Cumul Mass Fraction at Time
```

Option A selects the drop category:

```
DCA Results>Evap>What

               What Drop Category to Plot
                                               (Avg Dia)
             A-Drop Category  1                    106.40 mic
             B-Drop Category  2                    138.60 mic
             C-Drop Category  3                    171.00 mic
             D-Drop Category  4                    203.40 mic
             E-Drop Category  5                    235.90 mic
             F-Drop Category  6                    268.30 mic
             G-Drop Category  7                    301.30 mic
             H-Drop Category  8                    334.80 mic
             I-Drop Category  9                    366.70 mic
             J-Drop Category 10                    398.20 mic
             K-Drop Category 11                    430.70 mic
```

This table permits selection of the drop category to plot, and indicates the initial drop size for each Upper Diameter, Average Diameter, or Quadratic Equation (1st coefficient shown).

Option B permits selection of a calculation time at which to compare the Mass Fraction and/or Cumulative Mass Fraction with initial values.

```
DD Results>Canopy

               Canopy Plots

             A-Select Drop Category for Plots         1
             B-Material Fraction Remaining
             C-Composite Fraction Remaining
```

Option B plots the loss of Material Fraction due to interception with the canopy. The Composite Fraction Remaining sums all drop sizes with their mass fractions to give an overall result through the canopy.

```
DE Results>Wake

               Near Wake Plots

             A-Select Drop Category for Plots         1
             B-Select Dispersion Units        drops / sq m
             C-Select Dispersion Contrib      non-volatile
             D-Select Vertical Flux Position        .0 m
             E-Plot Mean Drop Trajectories
             F-Plot Mean+Std Dev Trajectories
             G-Continuous Deposition
             H-Vertical Flux Profile
             I-Drift Fraction Time History
```

Option A is applicable for plots E and F only. Option B selects the deposition units for plots G and H with the menu:

```
DEB Results>Wake>Disp Units

               Dispersion Units (deposition)

             A-Drops in Numerator
             B-Volume in Numerator
             C-Mass in Numerator
             D-Area Units for Denominator
             e-Volume Units for Denominator
             f-Time Units

               Current: drops / sq m
```

Option B here gives the volume units available in FSCBG; option C gives the mass units; and option D gives the area units (all from Table 1). Options E and F are available for Dosage and Concentration in Dispersion.

Back in the Near Wake Results Menu, option C permits the selection of dispersion contribution type to plot option G, H and I:

```
DEC Results>Wake>Contrib

               Select Dispersion Contribution

             A-Total Non-Gaseous
             B-Non-Volatile
             c-Gaseous
```

FSCBG solves for all dispersion options; this menu permits the user to plot the volatile and nonvolatile contribution; or the nonvolatile contribution; or the gaseous contribution (for dosage and concentration).

Back in the Near Wake Results Menu, option D selects the horizontal location at which to position the plane through which the flux is to be computed in plot option I.

Options G, H and I are computed before plotting. An intermediate menu is first displayed:

```
DEG Results>Wake>Depos

                Continuous Deposition

              A-Plot Results
              B-Append Results to Print File
              c-Export Results to Data File
```

Option B will add the computed results to the existing PRT file in a two-column format of distance and computed variable. Option C will permit exporting of these results to a data file for transfer to other applications. In all cases, Plot Results will lead to a Status Table:

```
DEGA Results>Wake>Depos>Cont Dep

                 Near Wake Plot Construction

Continuous Deposition
   Drop Category (__ Total):
   Initial Drop Diameter:
   Simulation Time:
   Lagrangian Equations (__ Total):
```

For option H the title is:

```
Vertical Flux
```

For option I the title is:

```
Drift Fraction

DF Results>Disp

               Dispersion Results

             A-Select Dispersion Variable      deposition
             B-Select Drop Category Range               1
             C-Select Dispersion Units         drops  / sq m
             D-Select Dispersion Contrib       non-volatile
             E-Select Receptor Grid Level              .0 m
             F-File Combination                        no
             G-Receptor Grid Results
             H-Discrete Receptor Results
             I-Area Coverage Results
```

Option A selects the variable to plot, with the available variables set by Model Selection. Option A leads to:

```
DFA Results>Disp>Var

               Dispersion Plot Variable

             a-Dosage
             b-Concentration
             C-Deposition
```

Option B in the Dispersion Results Menu selects the drop category to plot:

```
DFB Results>Disp>DC Rng

               Drop Category Range

             A-Single Drop Category
             B-Total of All Drop Categories
             C-Volume Median Diameter
             D-Number Median Diameter
```

One drop size may be plotted with Option A; all of them combined with Option B; or VMD or NMD with Options C and D respectively.

Option C in the Dispersion Results Menu selects the dispersion units consistent with the Dispersion Variable selected. Option D selects the Dispersion Contribution. Option E leads to:

```
DFE Results>Disp>Z Level

               Receptor Grid Level

             A-Level 1                          .0 m
```

If more than one level of receptor grids were entered on input, a selection could be made of which one to plot.

Option F permits combining the present results with previous results to simulate serpentine application. FSCBG checks to make sure the Receptor Grid is the same for both results.

Option G leads to:

```
DFG Results>Disp>Grid

               Receptor Grid Dispersion

             A-Contour Plot
             B-3D Plot
             C-B/T Elevation Plot
             D-L/R Elevation Plot
             E-Append Results to Print File
             f-Export Results to Data File
```

The new plot option is Option A: Contour Plots. This leads to a menu that includes Option C-What to Plot:

```
DFGAC Results>Disp>Grid>Contour>What

               What to Include in the Dispersion Contour Plot

             A-Auto Isopleth Levels                  yes
             b-Isopleth Levels
             C-Grid Locations                        yes
             D-Flight Lines                          yes
```

Options A and B set Isopleth Levels and lead to a menu for user entry. Options C and D are yes/no for inclusion in the plot.

Append Results adds the two-dimensional grid (X and Y) dispersion values to the PRT file.

Option H in the Dispersion Results Menu selects Discrete Receptors as opposed to the Receptor Grid:

```
DFH Results>Disp>Disc

               Discrete Receptor Dispersion

             A-B/T Elevation Plot
             B-L/R Elevation Plot
             C-Append Results to Print File
             d-Export Results to Data File
```

Option I in the Dispersion Results Menu selects Area Coverage:

```
DFI Results>Disp>Area

               Area Coverage

             A-Display Results
             B-Define Area Coverage Geometry
             C-Append Results to Print File
             d-Export Results to Data File
```

Option B permits the user to establish the area within which to compute statistics. On the screen the user moves the cursor to a beginning position with the cursor arrow keys; presses "." to anchor the line; then moves with the cursor arrow keys until the area is completed. Option A then presents the computations of Area; Minimum; Average; Maximum and Standard Deviation within the area described for the conditions specified in the Dispersion Results Menu. In addition the total area is scanned for Overall Maximum and (for deposition) the percentage of material recovered in the described geometry. A table also shows the amount of described area covered with at least certain levels of Overall Maximum.

7. EXIT

When EXIT is selected in the Main Menu, the Exit Verification menu will appear:

```
    Exit FSCBG

A-Do Not Exit, Return to FSCBG
B-Exit
```

If data changes have occurred or calculations have been performed and the data has not been saved, this menu will be preceded by the menu:

```
    Save Changed Data and Calculations

A-No
B-Yes
```

8. OTHER FEATURES

Command Line Inputs

FSCBG may be initiated in one of two ways:

```
FSCBG <return>
```

after which the user will be in the program but will have to move to File after the opening screen to input the filename to Open/Save; or

```
FSCBG  filename <return>
```

which performs the file open/save operation before the opening screen.

Batch Mode is handled on the command line also, with the two options:

```
FSCBG filename /b <return>
```

or

```
FSCBG filename /bf <return>
```

to run either Do Calculations (/b), or Force All Calculations (/bf). At the conclusion of the calculations, FSCBG will exit. Thus, any number of FSCBG runs may be initiated in a batch file on the personal computer, and run overnight, for instance.

9. REFERENCES

Barry, J. W. and R. B. Ekblad. 1983. Forest service spray drift modeling 1971-1982. ASAE Paper No. 83-1006. Bozeman, MT: ASAE.

Bilanin, A. J. and M. E. Teske. 1984. Numerical studies of the deposition of material released from fixed and rotary wing aircraft. NASA Contractor Report No. 3779.

Bilanin, A. J., M. E. Teske, J. W. Barry and R. B. Ekblad. 1989. AGDISP: the aircraft spray dispersion model, code development and experimental validation. *Transactions of the ASAE* 32: 327-334.

Bjorklund, J. R., C. R. Bowman and G. C. Dodd. 1988. User manual for the FSCBG aircraft spray and dispersion model version 2.0. Report No. FPM 88-5. USDA Forest Service, Forest Pest Management, Davis, CA.

Boyle, D. G., J. W. Barry, C. O. Eckard, W. T. Taylor, W. C. McIntyre, R. K. Dumbauld and H. E. Cramer. 1975. DC-7B aircraft spray system for large-area insect control. Report No. DPG-DR-C980A. U. S. Army Dugway Proving Ground, Dugway, UT.

Cramer, H. E., J. R. Bjorklund, F. A. Record, R. K. Dumbauld, R. N. Swanson, J. E. Faulkner and A. G. Tingle. 1972. Development of dosage models and concepts. Report No. DTC-TR-72-609-I. U. S. Army Dugway Proving Ground, Dugway, UT.

Curbishley, T. B. and P. J. Skyler. 1989. Forest service aerial spray computer model -- FSCBG (PC) - revision 1. Report No. FPM 89-1. USDA Forest Service, Forest Pest Management, Davis, CA.

Dumbauld, R. K., H. E. Cramer and J. W. Barry. 1975. Application of meteorological prediction models to forest spray problems. Report No. DPG-TR-M935P. U. S. Army Dugway Proving Ground, Dugway, UT.

Dumbauld, R. K. and J. R. Bjorklund. 1977. Deposition profile calculations for the state of Maine 1977 spray program. Technical Report No. TR-77-310-01. H. E. Cramer Company, Inc., Salt Lake City, UT.

Dumbauld, R. K., J. E. Rafferty and J. R. Bjorklund. 1977. Predictions of spray behavior above and within a forest canopy. Report No. TR-77-308-01. H. E. Cramer Company, Inc., Salt Lake City, UT.

Dumbauld, R. K., J. R. Bjorklund and S. F. Saterlie. 1980. Computer models for predicting aircraft spray dispersion and deposition above and within forest canopies: users manual for the FSCBG computer program. Report No. 80-11. Prepared under Contract No. 53-91S8-9-6127 by H. E. Cramer Company, Inc. for USDA Forest Service, Forest Pest Management, Methods Application Group, Davis, CA.

Dumbauld, R. K., C. R. Bowman and J. E. Rafferty. 1980. Optimum swath widths and application rates for selected aircraft and meteorological regimes. Report No. 80-5. Prepared under Contract No. 53-91S8-9-6260 by H. E. Cramer Company, Inc. for USDA Forest Service, Forest Pest Management, Methods Application Group, Davis, CA.

Golovin, M. N. and Putnam, A. A. 1962. Inertial impaction on single elements. *I & EC Fundamentals* 1:264-273.

Grim, B. S. and J. W. Barry. 1975. A canopy penetration model for aerially disseminated insecticide spray released above coniferous forests. Report No. 2425 MEDC. USDA Forest Service, Equipment Development Center, Missoula, MT.

Hardy, C. E. 1987. Aerial application equipment. Report No. 8734-2804 MEDC. USDA Forest Service, Equipment Development Center, Missoula, MT.

Herdan, G. 1960. Small Particle Statistics. London: Buttersworths.

Lyman, W. J., W. F. Reehl and D. H. Rosenblatt. 1990. Handbook of Chemical Property Estimation Methods. Washington, D. C.: American Chemical Society.

Pulley, R. A. and J. K. Walters. 1990. The effect of interception on particle collection by spheres and cylinders. *Journal of Aerosol Science* 21: 733-743.

Rafferty, J. E., R. K. Dumbauld, H. W. Flake, J. W. Barry and J. Wong. 1982. Comparison of modeled and measured deposition for the withlacoochee spray trials. Report No. FPM 83-1. Final Report under Contract No. 53-91S8-9-6260 by H. E. Cramer Company, Inc. for USDA Forest Service, Forest Pest Management, Davis, CA.

Rafferty, J. E., J. M. White, J. F. Bowers and R. K. Dumbauld. 1989. Forest spray dispersion study: comparison of measured deposition with

FSCBG2 model predictions. In *Proceedings Agricultural and Forest Meteorology Conference*, 200-203. Charleston, SC: American Meteorological Society.

Skyler, P. J. and J. W. Barry. 1991. Final report - compendium of drop size spectra compiled from wind tunnel tests. Report No. FPM 90-9. USDA Forest Service, Forest Pest Management, Davis, CA.

Teske, M. E. 1990. AGDISP user manual mod 6.0. Technical Note No. 90-16. Prepared under Contract No. 53-0343-9-00076 by Continuum Dynamics, Inc. for USDA Forest Service, Technology and Development Center, Missoula, MT and Forest Pest Management, Davis, CA.

Teske, M. E. 1991. SDC: size distribution calculation - user manual. Report No. 9134-2810 MTDC. Prepared under Contract No. 53-0343-9-00076 by Continuum Dynamics, Inc. for USDA Forest Service, Technology and Development Center, Missoula, MT.

Teske, M. E., K. P. Bentson, R. E. Sandquist, J. W. Barry and R. B. Ekblad. 1991. Comparison of FSCBG model predictions with heather seed orchard deposition data. *Journal of Applied Meteorology* 30: 1366-1375.

Waldron, A. W. 1975. An engineering approach to the problem of maximizing zectran particle capture on spruce budworms in a dense coniferous forest. Report No. DPG-TN-M605P. U. S. Army Dugway Proving Ground, Dugway, UT

Weast, R. C. 1981. Editor. CRC handbook of chemistry and physics (62nd edition). D190-D193. Boca Raton: CRC Press Inc.

10. INDEX

The following index locates each program input by its path from the Main Menu.

Volatile Fraction of Carrier	BGD
Vortex Decay Coefficient	BIA
Wake Settling	BBAB
Weight	BECA
Wind Speed at 10 meters	BIFA
Wingspan	BECB
Within Canopy (Meteorology)	BIE

11. FSCBG DATA INPUT SHEET

Following are six pages of data input sheets to aid in the collection and entering of data into FSCBG.

FSCBG DATA INPUT SHEET

Family File Name ________________

Run Title ____

MODEL CHOICES

Wake Option: (Choose 1)
- None ____
- Wake Settling (Simple Wake) _____
- Near Wake (AGDISP) ____

Evaporation Model Off ____ On ____

Canopy Model Off ____ Story ____ Licor ____

Dosage Model Off ____ On ____
Concentration Model Off ____ On ____
Deposition Model Off ____ On ____

RECEPTOR GRID

Grid Orientation/Units _____/_____

Grid Height(s) (max. 3 values) Units _____

____
____
____

Grid X Locations: (max of 100 values) Units _______

______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______

Grid Y Locations: (max of 100 values) Units _______

______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______
______	______	______	______	______	______	______	______	______

Discrete Receptors: (max. of 100 values)   Units ______

X Coordinate	Y Coordinate	Height
____________	____________	______
____________	____________	______
____________	____________	______
____________	____________	______

CANOPY

Tallest Canopy Characteristics:

Height/Units	Stand Density (Stems/Acre)	Probability of Penetration	Element Size /Units
______/_____	____________	______________	_______/______

Envelope for Tallest Canopy: (max. of 20 values)

Height	Diameter
______	________
______	________
______	________
______	________
______	________

Middle Canopy Characteristics:

Height/Units	Stand Density (Stems/Acre)	Probability of Penetration	Element Size /Units
______/_____	____________	______________	_______/______

Envelope for Middle Canopy: (max. of 20 values)

Height	Diameter
______	________
______	________
______	________
______	________
______	________

Smallest Canopy Characteristics:

Height/Units	Stand Density (Stems/Acre)	Probability of Penetration	Element Size /Units
______/_____	____________	______________	_______/______

Envelope for Smallest Canopy: (max. of 20 values)

Height	Diameter
______	________
______	________
______	________
______	________
______	________

LiCor Canopy Input

Height of Foliage/Units _______/_______

Element Size/Units _______/_______

Licor Canopy Measurements:

	Degrees	Emission Level
A	7	_______
B	23	_______
C	38	_______
D	53	_______
E	68	_______

Leaf Area Density: (Use consistent units - max. of 20 values)

Height/Units _____	L.A.D.
______	______
______	______
______	______
______	______
______	______

AIRCRAFT

Name ______________________________   Weight/Units _______/_______

Sample: 10,500 lbs (MAX T.O. Weight) Aircraft w/full tank
+ 6,089 lbs (empty aircraft)
16,589 (divided by 2 = 8,295 lbs

Helicopter

Rotor Diameter/Units ______/_____   Blade RPM _________

Fixed Wing (Including Bi-Plane)

Wingspan/Units _____/_____
Vertical Distance Between Wings/Units (Bi-Plane only) _______/_______

Planform Area/Units _____/______   Drag Coefficient ________

Propeller Radius/Units ______/_______   Propeller Efficiency _______

Blade RPM _______

Jet

Wingspan/Units ____/____   Jet Exit Radius/Units____
Jet Thrust/Units ____/____

Fixed Wing/Jet
(max. of 4 engines)

Engine Location(s): Forward/Units _______/_______ (enter once)

Lateral/Units _______/_______ (enter for each engine)

Vertical/Units _______/_______ (enter for each engine)

SPRAY SYSTEM

Nozzle Locations: Forward/Units ______/______ (enter once)

Lateral	Vertical
Units _______	Units ________
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______
_______	_______

Enter lateral and vertical locations for each nozzle. Maximum of 20 nozzles.

SPRAY MATERIAL

Tank Mix ______________________________ (Information only)

Density _______ g/cm3 Volatile Fraction ________

Mass Size Distribution (Max. 16 size categories)

Upper Diameter (Microns)	OR	Average Diameter (Microns)	Mass Fraction
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______
_______		_______	_______

SOURCE GEOMETRY

Spraying Speed/Units ______/_____ Height of Spray Release/Units (Always measure from ground) ______/_____

Emission Rate (Application Rate)/Units _______/_______

Swath Width (Distance between flight lines)/Units _______/_______

Source Line Location (Flight Lines) - (Max. 100 flight lines)

Units _______

X Begin	Y Begin	X End	Y End
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______
_______	_______	_______	_______

METEOROLOGICAL DATA

Surface Pressure/Units ______/_____ Net Radiation Index _____

Open Terrain

Height Units _____	Temp/ Units _____	% RH	Wind Speed Units _____	Wind Direction (From) Units _____

Within Canopy

Height Units _____	Temp/ Units _____	% RH	Wind Speed Units _____	Wind Direction (From) Units _____